AD-A149 940 COOPER RIVER REDIVERSION PROJECT LAKE MOULTRIE & SANTEE 1/1
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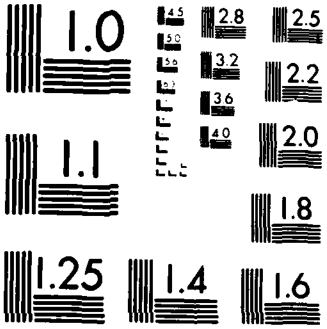

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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AD-A149 940

DESIGN MEMORANDUM NO. 15

COOPER RIVER REDIVERSION PROJECT
LAKE MOULTRIE & SANTEE RIVER
SOUTH CAROLINA

WATER
MONITORING PLAN

"Original contains color plates: All DTIC reproductions will be in black and white"

U.S. ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
Charleston, South Carolina
REVISED MARCH 1978

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DEPARTMENT OF DEFENSE

DEPARTMENT OF THE ARMY
CHARLESTON DISTRICT CORPS OF ENGINEERS
P O BOX 919
CHARLESTON SOUTH CAROLINA 29402

SACEN-E
~~SADEN-E~~

23 December 1977

SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, S. C., Design Memorandum 15, Water Quality Monitoring Plan

Division Engineer, South Atlantic
ATTN: SADEN-E

1. References:

a. SADEN-E letter dated 17 November 1976, subject: Water Quality Studies - Cooper River Rediversion Project.

b. SADEN-G letter dated 7 December 1977, subject: Cooper River Rediversion Project, Lake Moultrie and Santee River, S. C., Supplement No. 2 to General Design Memorandum - Requirements for Protection of Bushy Park Reservoir.

2. Attached for review and approval is the subject DM.

3. The probable land requirements are addressed in general terms in Section 15.f. of the subject DM. It is suggested that the questions raised in reference b. concerning real estate acquisition be held in abeyance until the subject DM is approved, at which time, they could be resolved by Savannah Real Estate Division as part of that Division's activity in acquiring the necessary real estate instruments.

FOR THE DISTRICT ENGINEER:

1 Incl (10 cys)
as

JACK J. LESEMANN
Chief, Engineering Division

SADEN-GP (23 Dec 77) 1st Ind
SUBJECT: Cooper River Rediversion Project, Design Memorandum 15, Water
Quality Monitoring Plan

DA, South Atlantic Division, Corps of Engineers, 510 Title Building,
30 Pryor Street, S. W., Atlanta, Georgia 30303 10 February 1978

TO: District Engineer, Charleston, ATTN: SACEN-E

1. The Design Memorandum is approved subject to the following comments:

a. Page 4, paragraph 8. Water use classification. Suggest using a single line drawing in addition to this paragraph to show classification and relation to tributaries similar to attached drawing.

b. Page 11, paragraph 11. Environmental Protection Agency, (EPA) 1974. The maximum penetration (between mile 33.2 and 33.5) should be shown on a map of the area, i.e., plate 1. River mile 42, discussed in succeeding paragraph 13 should also be shown.

c. Page 13, paragraph 15. Cooper River. Suggest revising last sentence, 1st paragraph somewhat as follows: Durham Canal would also be monitored to document water quality conditions in Back River.

d. Page 16. The last sentence in paragraph 15.f. should be deleted as it is redundant and unnecessarily speculative in nature.

e. Biological and chemical sampling is needed in the Cooper, Santee, and Back Rivers to assure availability of pre and post rediversion data as contained in the proposed Water Quality Work Plan discussed at the Corps/USGS, 23 July 1975 meeting in Columbia, SC. Consideration should be given to having the biological studies incorporated in the U. S. Fish and Wildlife Service's 10 year study to establish a data base for pre and post rediversion.

f. The subject DM contains plans for the collection of a significant amount of data on water levels and streamflow which does not appear to be directly related to the water quality or environmental needs of the project. These items were not discussed at previous meetings on water quality data needs for the subject project but appear to be a significant portion of the total O&M cost for the subject plan. Furthermore, the prediversion water quality data collection program within Lake Moultrie and the biological and chemical data collection program for the Cooper and Santee Rivers which have been previously discussed are not included in the subject plan. The plans for collection of streamflow and water level information would appear more appropriate as part of the hydrological-meteorological data collection network plan. If the streamflow and water level data collection plan is to be included within the subject DM, suggest the name of the subject DM be changed to Water Control Monitoring Plan.

g. Due to the nature and cost of continuous electronic monitoring, only essential stations should be installed. We seriously question the need for the continuous monitor system at Pimlico, Station C1. We recommend this station be deleted unless additional rationale is provided by District as it is above the area of concern at Bushy Park.

SADEN-GP (23 Dec 77) 1st Ind 10 February 1978
SUBJECT: Cooper River Rediversion Project Design Memorandum 15, Water Quality Monitoring Plan

h. In order to insure earlier detection of possible salinity, the intake for Durham Canal monitor should be located at mid-depth in lieu of upper level.

i. As large amounts of data will be produced by subject plan, information should be included in the DM on data processing, analysis and storage. Will STORET be utilized as suggested by ER 1130-2-334?

j. River mile locations should be shown on the plates and figures since they are frequently referenced in the DM.

k. The DM should be coordinated with the State of South Carolina, the U. S. Environmental Protection Agency, and the Fish and Wildlife Service to insure that all potential problem areas are being addressed.

FOR THE DIVISION ENGINEER:

Incl wd

WILLIAM N. McCORMICK, JR.
Chief, Engineering Division

Copy Furnished:
HQDA (DAEN-CWE-BR)
w/5 cys Incl

SACEN-E (23 Dec 77) 2nd Ind
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee
River, S. C., Design Memorandum 15, Water Quality Monitoring Plan

DA, Charleston District, Corps of Engineers, P. O. Box 919, Charleston,
South Carolina 29402 10 April 1978

TO: Division Engineer, South Atlantic, ATTN: SADEN-GK

1. Report containing revisions suggested in 1st Indorsement is inclosed. The information in the following paragraphs is provided in response to comments by your office. Responses are referenced to paragraphs in 1st Indorsement.

2. Paragraph a. Included in Plate 1.

3. Paragraph b. River mileage has been added to Plate 1. Mileage figures shown in the report and on Plate 1 correspond to the same location given in the EPA report although the mileages are different.

4. Paragraph c. Revised as suggested.

5. Paragraph d. Revised as suggested.

6. Paragraph e. The chemical sampling program is included in paragraph 2 D. Consideration will be given to having the biological studies incorporated in the U. S. Fish and Wildlife Service's 10-year study to establish a data base for pre- and post rediversion.

7. Paragraph f. Name of subject DM has been changed to "Water Monitoring Plan."

8. Paragraph g. The relevance of conductivity monitoring at the four monitoring stations below Pimlico depends on the conductivity of water entering the area to be monitored. Unless this inflow is monitored, it is possible that discharges above Pimlico could result in an increase in conductivity which, in the absence of a monitoring station at or above Pimlico could be attributed to salt water intrusion from the ocean. In view of the criticality of water salinity at Bushy Park and the great controversy which would ensue over any detectable increase in salinity, a monitoring station at Pimlico is considered to be critical. It should be noted that there is significant congressional interest in this aspect of the project, stimulated by the Cooper River Water Users Association, and furthermore, the data to be provided by the monitor at Pimlico may be needed to protect the Federal Government from future claims.

SACEN-E 10 April 1978
SUBJECT: Cooper River Rediversion Project, Lake Moultrie and Santee River, S. C., Design Memorandum 15, Water Quality Monitoring Plan

9. Paragraph h. Since the salt wedge tends to move along the bottom, the intake for the Durham Canal monitor will have a bottom intake.

10. Paragraph i. Data will be analyzed and summarized by the USGS as discussed in paragraph 28 of this report. If EPA wishes to include the data in the STORET system, it will be made available to them.

11. Paragraph j. River miles have been included in Plate 1.

FOR THE DISTRICT ENGINEER:

1 Incl (10 cys)
as

JACK J. LESEMANN
Chief, Engineering Division

COOPER RIVER REDIVERSION PROJECT

LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

Design Memorandum No. 15

Water Control Monitoring Plan

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COOPER RIVER REDIVERSION PROJECT

LAKE MOULTRIE AND SANTEE RIVER, SOUTH CAROLINA

DESIGN MEMORANDUM 15

WATER QUALITY MONITORING PLAN

INTRODUCTION

1. Purpose. The purpose of this design memorandum is to present for review and approval a detailed plan for monitoring water quality, flows and stage in the water systems which are expected to be subject to significant project effects and determining the effect of freshwater flow changes in the Cooper River on the hydraulic, salinity, and shoaling characteristics in Charleston Harbor. The present plan includes costs for equipment, operation and maintenance, and details of information to be collected by the program.

2. Scope. This design memorandum covers pre-project as well as post-project conditions to permit necessary comparison of data to determine project impacts. The monitoring arrangement for the Cooper River would be sufficiently sophisticated to permit early warning necessary to make appropriate releases in accordance with the operations manual at the Jefferies Hydroplant to repel any salinity threat to industries utilizing Bushy Park Reservoir as a source of fresh water. The monitoring arrangement for Charleston Harbor would provide information on stratification and shoaling.

3. Authorization. The Cooper River Rediversion Project, which will reduce shoaling and restore the historic saline regimen to Cooper River and Charleston Harbor, was authorized by the River and Harbor Act of 1968 (P.L. 90-483, 90th Congress, S. 3710, August 13, 1968). Section 101 of the 1968 Act is quoted in part as follows:

> "....That the following works of improvement of rivers and harbors and other waterways for navigation, flood control and other purposes are hereby adopted and authorized to be prosecuted under the direction of the Secretary of the Army and supervision of the Chief of Engineers, in accordance with the plans and subject to the conditions recommended by the Chief of Engineers, in the respective reports hereinafter designated.... Cooper River, Charleston Harbor, South Carolina: Senate Document Numbered 88, Ninetieth Congress, at an estimated cost of $35,381,000..."

This report is prepared in accordance with applicable instructions in ER 1110-2-1150.

4. Project description. A serious silt and shoaling problem developed in Charleston Harbor subsequent to 1942 when silt-laden fresh water of

Santee River was diverted through Jefferies Hydropower Plant, to the Cooper River and into the salt water of the harbor. This diversion creates density currents, which tend to entrap sediment. The project will provide for rediversion of most of the Santee River waters from above Jefferies Hydropower Plant into the Santee River through a proposed canal about 11.7 miles in length. The canal would begin at the northeast corner of Lake Moultrie and proceed generally eastward to a proposed hydroelectric plant just north of St. Stephen, South Carolina, then continue on to an intersection with the Santee River at Mattassee Lake. The 84,000 kilowatt hydroelectric plant would generate power using the rediverted flow in the canal and compensate for the limitation in flow and loss of power at the existing Pinopolis plant (Jefferies Hydroplant) owned and operated by the South Carolina Public Service Authority. The plan provides for fish and wildlife facilities, including a fish lift at the new power plant and a replacement fish hatchery on the canal bank below the power plant.

There is no requirement of local cooperation, and the costs to the United States shall not include betterments to others arising from the increase in capacity provided by the new power facility. The Secretary of the Army, acting through the Chief of Engineers, is authorized to determine and enter into agreement with South Carolina Public Service Authority, or its successors, in interest, for apportionment of costs between the United States and the South Carolina Public Service Authority.

5. Related reports.

a. Special Report on the Water Quality at Bushy Park dated 21 October 1975.

b. Supplement No. 2 to General Design Memorandum - Requirements for Protection of Bushy Park.

c. Appendix A dated March 1976 to Supplement No. 2 to General Design Memorandum - Bushy Park Water Supply Tests transmitted 4 August 1976.

6. Responsibility. Corps of Engineers responsibilities in water quality relate to changes which occur as a result of project construction or operation. Primary changes which could occur as a result of this project are advancing and receding salinity fronts, turbidity and water color changes, and stage variations.

BASIC CRITERIA

7. Location of the study area. Waters which may be affected by the project include the Cooper and Santee Rivers, Durham Creek Canal (Durham Canal) and Back River (Bushy Park Reservoir), Lake Moultrie, and portions of the Atlantic Intracoastal Waterway (AIWW). These waters are all located in the southeastern portion of South Carolina as shown on Plate 1.

8. Water use classifications. The present South Carolina water use classifications for the various streams in the study area are as follows (also see Plate 1):

Water	Classification
Back River: The entire stream tributary to the Cooper River	B
Cooper River: U. S. Highway 52 to a point approximately 30 miles above junction with Ashley River	B
Cooper River: From a point approximately 30 miles above junction with Ashley to the junction with the Ashley River	SC
AIWW: From junction with North Santee River to Ben Sawyer Bridge (near Charleston Harbor)	SA
Santee River: From Lake Marion to North and South Santee Rivers	B
North Santee River:	
U. S. 17 to 1,000 feet below the AIWW	SB
From 1,000 feet below the AIWW to Atlantic Ocean	SA
South Santee River:	
U. S. 17 to 1,000 feet below the AIWW	SB
From 1,000 feet below the AIWW to Atlantic Ocean	SA

9. South Carolina water quality standards. The applicable water quality standards are as follows:

a. Class B. Fresh waters suitable for domestic supply after conventional treatment in accordance with requirements of the South Carolina State Board of Health and Environmental Control. Suitable also for propagation of fish, industrial and agricultural uses and other uses requiring water of lesser quality.

QUALITY STANDARDS FOR CLASS B WATERS

Item	Specifications
1. Toxic wastes, deleterious substances, colored or other wastes.	None in amounts exceeding limitations established and adopted by the Department of Health and Environmental Control to protect waters of this class. In establishing and adopting limits the Department of Health and Environmental Control will be guided by Section 1412 Public Health Service Act, amended by the Safe Drinking Water Act (P.L. 93-523) and related regulations.
2. Dissolved oxygen.	Daily average not less than 5 mg/l with a low of 4 mg/l except that swamp waters may have an average of 4 mg/l.
3. Fecal coliform.	Not to exceed a geometric mean of 1000/100 ml based on five consecutive samples during any 30 day period; nor to exceed 2000/100 ml in more than 20% of the samples examined during such period (not applicable during or following periods of rainfall).
4. pH.	Range between 6.0 and 8.5 except that swamp waters may range from pH 5.0 to pH 8.5.

b. Class SA. Tidal salt waters suitable for propagation, survival, and harvesting of shellfish for market purposes as designated by the Department of Health and Environmental Control. Suitable also for uses requiring water of lesser quality.

QUALITY STANDARDS FOR CLASS SA WATERS

Item	Specifications
1. Garbage, cinders, ashes, oils, sludge or other refuse.	None.
2. Sewage or waste effluents.	None which are not effectively treated and disinfected.

3. Toxic wastes, deleterious substances, colored or other wastes.	None alone or in combination with other substances or wastes in sufficient amounts as to be injurious to edible fish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor, or sanitary condition thereof or impair the waters for any other best usage as determined for specific waters which are assigned to this class.
4. Dissolved oxygen.	Not less than 5 mg/l.
5. Organisms of coliform group.	Not to exceed a median coliform of 70/100 ml, nor shall more than 10% of the samples in a five (5) tube dilution test exceed a MPN of 230/100 ml; or current Department of Health and Environmental Control and U. S. Food and Drug Administration standards.
6. pH.	Shall not vary more than 3/10 of a pH unit above or below that of effluent-free waters in the same geological area having a similar total salinity, alkalinity and temperature.

c. Class SB. Tidal salt waters suitable for direct water contact and for survival and propagation of shellfishing except shellfishing for market purposes. Suitable also for uses requiring water of lesser quality.

QUALITY STANDARDS FOR CLASS SB WATERS

Item	Specifications
1. Garbage, cinders, ashes, oils, sludge or other refuse.	None.
2. Sewage or waste effluents.	None which are not effectively disinfected.
3. Toxic wastes, deleterious substances, colored or other wastes	None alone or in combination with other substances or wastes in sufficient amounts as to be injurious to edible fish or the culture or propagation thereof, or which in any manner shall adversely affect

	the flavor, color, odor, or sanitary condition thereof; to make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
4. Dissolved oxygen.	Not less than 5 mg/l.
5. Fecal coliform.	Not to exceed a geometric mean of 200/100 ml; nor shall more than 10% of the samples in any 30 day period exceed 400/100 ml.
6. pH.	Shall not vary more than one-half of a pH unit above or below that of effluent-free waters in the same geological area having a similar total salinity, alkalinity and temperature, but not lower than 6.75 or above 8.5.

d. Class SC. Tidal salt waters suitable for crabbing, commercial fishing and for the survival and propagation of marine fauna and flora.

QUALITY STANDARDS FOR CLASS SC WATERS

Item	Specifications
1. Garbage, cinders, ashes, oils, sludge or other refuse.	None.
2. Toxic wastes, oils, deleterious substances, colored or other wastes.	None alone or in combination with other substances or wastes in sufficient amounts as to be injurious to edible fish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor, or sanitary condition of fish or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
3. Dissolved oxygen.	Not less than 4 mg/l.
4. Fecal coliform.	Not to exceed a geometric mean of 1000/100 ml based on five consecutive samples during any 30 day period; nor exceed 2000/100 ml in more than 20% of the samples examined during such period (not applicable during or immediately following periods of rainfall).

5. pH.	Shall not vary more than one pH unit above or below that of effluent-free waters in the same geological area having a similar total salinity, alkalinity and temperature but not lower than 6.75 or above 8.5.

PRIOR STUDIES

10. Federal Water Pollution Control Administration (FWPCA), 1966. In June 1966, the FWPCA under contract to the Charleston District prepared "A report on the water quality of Charleston Harbor and the effects thereon of the proposed Cooper River Rediversion." The purpose of this study was to determine existing water quality as measured by various bacteriological, biological, chemical, and physical parameters; investigate the effects of interactions of these parameters on environmental changes; and predict the effects of reduced flow on water quality. The area of study included the lower reaches of the Ashley, Cooper, and Wando Rivers and Charleston Harbor.

11. Environmental Protection Agency (EPA), 1974. In April 1974, the EPA published the results of its "Cooper River Environmental Study." A major portion of this study was conducted during a ten day period when water releases from the Pinopolis Dam were adjusted to simulate post-rediversion conditions of flow. During this ten day period, the EPA found that the maximum penetration of the salt water wedge was between mile 33.2 and 38.5.

12. Corps of Engineers, 1975. In October 1975, the District completed a "Special Report on Water Quality at Bushy Park." This report presents a discussion of the various aspects of the Bushy Park water quality matter, including local concerns and proposed solutions. The report recommended that a monitoring system with early warning capabilities to allow timely implementation of corrective measures to prevent salinity intrusion into Bushy Park Reservoir be provided and studies be made to determine the most feasible means of assuring continuous flows of up to 5,000 cfs into the Cooper River at times when no power generation is possible.

13. Corps of Engineers, 1976. Design Memorandum 1, Supplement #2, Cooper River Rediversion Project, Requirements for Protection of Bushy Park Reservoir, February 1976. This report recommended that a monitoring system and emergency flow facility be provided as a means of safeguarding against salinity intrusion of Bushy Park Reservoir after rediversion. Appendix A of this report presented the results of studies on the "Bushy Park Water Supply Tests" completed by WES in November 1975. The study involved the use of the Cooper River hydraulic model to determine the maximum incursion of salt water under different conditions of flow. Under the worst case condition, the maximum saline advancement was at river mile 42. The results of these studies were considered in determining locations for sampling sites in this study.

WATER QUALITY MONITORING PROGRAM

14. General. This section presents a discussion of water quality studies to be accomplished in waters which may be impacted by the rediversion project. A breakdown of annual costs for the water quality program is presented in Table 1.

TABLE 1

Summary of Costs
Water Quality Studies

FY 1978	
1. Cooper River monitoring	
a. Three water quality monitoring sites - operation and maintenance	$30,000
b. Reconnaissance of Cooper River (Determine location of servo-programmers)	4,000
c. Three shelters and water intakes	10,500
d. Utilities installed	40,000
e. Two temporary servo-programmers	4,000
2. Santee River reconnaissance	3,000
3. Back River study	2,500
4. Lake Moultrie sediment analysis	5,000
Total 1978	$99,000
FY 1979	
1. Cooper River monitoring - O&M of five water quality stations	$50,000
2. Telemetry system	36,500
Total 1979	$86,500
FY 1980	
1. Cooper River monitoring - O&M of five water quality stations	$50,000
2. Chemical Sampling - Cooper, Santee and Back Rivers	8,500
3. Santee River sediment study	5,000
Total 1980	$63,500

TABLE 1 (Cont'd)

FY 1981	
1. Cooper River monitoring - O&M of five water quality stations	$50,000
2. Chemical Sampling - Cooper, Santee and Back Rivers	8,500
3. Monthly sampling near mouth of rediversion canal	2,000
Total 1981	$60,500
FY 1982	
1. Cooper River monitoring - O&M of five water quality stations	$50,000
2. Chemical Sampling - Cooper, Santee and Back Rivers	8,500
3. Monthly sampling near mouth of rediversion canal	2,000
Total 1982	$60,500
FY 1983	
1. Cooper River monitoring - O&M of five water quality stations	$50,000
2. Monthly/daily sampling near mouth of rediversion canal	12,500
3. Monthly sampling in Charleston Harbor	26,000
4. Chemical Sampling - Cooper, Santee and Back Rivers	8,500
Total 1983	$97,000
Post-rediversion	
1. Santee River reconnaissance	$ 3,000
Annual post-rediversion costs	
1. Cooper River monitoring - O&M of five water quality stations	$50,000
2. Chemical Sampling - Cooper, Santee and Back Rivers	8,500
3. Santee River - monthly turbidity	2,000
4. Monthly sampling in Charleston Harbor	26,000
Total	$86,500

15. Cooper River. The objective of the Cooper River monitoring program is to monitor changes taking place in Cooper River as a result of rediversion and to provide an early warning system so as to be able to take actions which will assure that no oceanic salt water will enter the Durham Canal during extreme, unexpected, abnormal conditions. Durham Canal would also be monitored to document water quality conditions in Back River.

a. To accomplish the objectives of this phase of the program, four water quality monitors (WQM) would be installed along the Cooper River and one will be installed in Durham Canal. Stage recorders would be installed at each of the five stations. The monitors would be located as follows:

(1) Pimlico (mile 44.4)

(2) Durham Canal - upstream of junction with Cooper River

(3) Vicinity of Dean Hall (mile 38.5)

(4) Below Dean Hall - exact location to be determined by initial studies

(5) Vicinity of Amoco facility (approximately mile 28) - exact location to be determined by initial studies

b. The precise location of monitors below Dean Hall would be based on an analysis of data collected by two servo-programmers. In order to determine the best location of these servo-programmers it will be necessary to conduct two reconnaissance surveys of the river; one at "spring" tide of the year and the other at "neap-" tide of the year. Conductivity readings taken at the surface and bottom would be used to detect the salt wedge as it moves upriver during two tidal cycles. Grab samples would be collected near the bottom at the upstream and downstream limits indicated by conductivity readings to verify the presence of salt water. An analysis of data collected on boat runs would assist in determining the location for the two servo-programmers. Data from the servo-programmers would be used to determine the location of two WQM's.

c. Parameters to be measured by WQM's are pH, dissolved oxygen (DO), specific conductance, and temperature. Data from the five monitors would be telemetered to the U. S. Geological Survey in Columbia, South Carolina. The primary use of the data at Columbia would be to ascertain that the WQM's are operating properly. In addition, after rediversion, data from the Dean Hall WQM and one of the WQM's downstream of Dean Hall would be telemetered to the Pinopolis Dam as part of the early warning system for detection of salt water intrusion. The movement of the salt wedge in the Cooper River would be shown by graph or by a family of curves based on data collected under this Water Quality Monitoring Plan.

d. The specific locations of monitors and parameters to be measured at each station are shown on Plate 1 and Table 2, respectively. Each of the five monitoring sites requires a 220-volt power source and it is deemed necessary that each site also be accessible by road. Figure 1 shows the roads and utility lines in the vicinity of the monitoring sites. Pimlico (C-1), Durham Canal (C-2), and Dean Hall (C-3) are now accessible by road and are also served by utility lines. The precise location of C-4 and C-5 would be determined during the course of the initial studies described in 15.b. The final selection of these sites may be influenced by accessibility and the availability of electricity. In this regard, the tentative locations of C-4 and C-5 shown in Plate 1 and Figure 1 are now accessible by road and are served by utility lines. Should initial studies indicate these tentative locations are unsuitable, Figure 1 gives an indication of the need for access roads and utility lines to serve other locations in the vicinity.

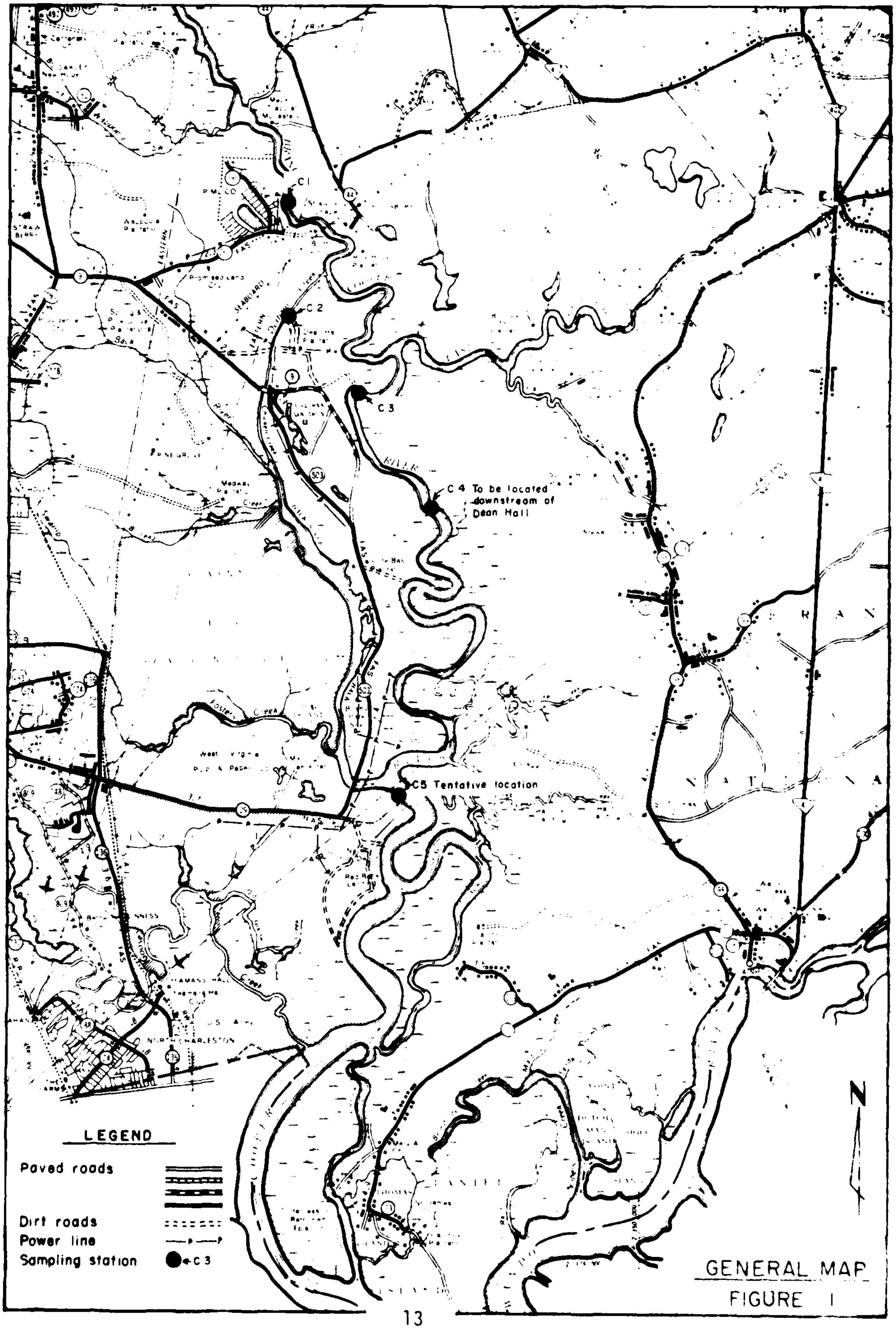
e. The monitoring equipment arrangement is shown in Figure 2. The equipment shelters would be prefabricated fiberglass units placed on piers in such a manner that the shelters extend over the water's surface. Shelter dimension would be approximately 10 feet by 6 feet by 6.5 feet high. Shelters would be insulated and air-conditioned to facilitate the operation of the monitoring equipment. Except for the stations at Pimlico and Durham Canal, the WQM's would have dual intakes and pumps leading to separate sample chambers. The bottom intake at each site would pump to a sample chamber containing only a specific conductance probe. The upper intake at each site would pump to a sample chamber containing pH, DO, specific conductance, and temperature probes. The probes from both sample chambers would be recorded by one monitor measuring specific conductance from the lower intake and pH, DO, temperature, and specific conductance from the upper intake. The WQM's at Pimlico and Durham Canal would have a bottom intake and would measure pH, DO, specific conductance, and temperature.

f. The land requirements for each unit would probably be less than 0.5 acre. Additional land could be required for access roads to sites C-4 and C-5 if the tentative locations shown in Plate 1 are later found by initial studies to be unsuitable. Since the primary purpose of the five WQM's is to insure that the Cooper River Rediversion Project does not cause any intrusion of salt water into the Bushy Park Reservoir, the length of time that monitoring would be done cannot be determined until the real likelihood of salt water intrusion has been determined by actual field experience with the monitoring system.

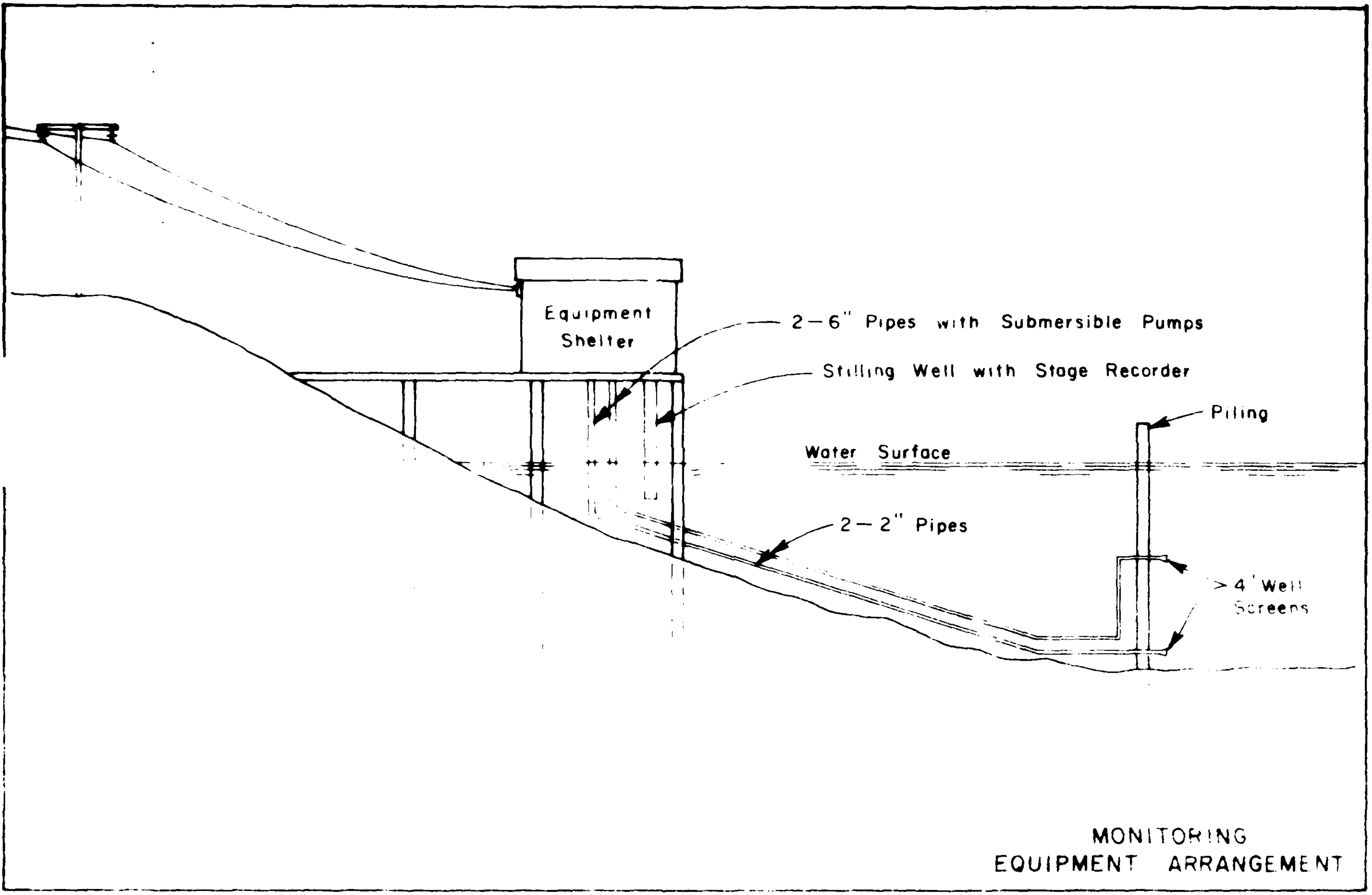
16. Lake Moultrie. In order to assure that toxic substances are not released during the dredging of the entrance channel, six sediment samples from the lake area to be dredged for the 2.6 mile entrance channel would be collected for chemical analysis prior to initiation of construction. Sample locations are shown on Figure 3. These samples would be analyzed for the following:

TABLE 2
SUMMARY OF WATER QUALITY STUDIES

Station	Location of Station	Parameters to be monitored	Samples per station	Sampling frequency	Remarks
1	Cooper River mile 44.4 (Pimlico	Specific conductance, Temperature, pH, Dissolved oxygen	Bottom	Continuous	Will be telemetered to Columbia [illegible]
[illegible]	At intake of [illegible] point in Durham Canal	Specific conductance, Temperature, pH, Dissolved oxygen	Bottom	Continuous	Will be telemetered to Columbia [illegible]
[illegible]	Cooper River mile 48 [illegible] Dean Hall	Specific conductance, Temperature, pH, Dissolved oxygen	Surface and Bottom	Continuous	Will be telemetered to Columbia [illegible] also to Pinopolis Dam
[illegible]	[illegible]	Specific conductance, Temperature, pH, Dissolved oxygen	Surface and Bottom	Continuous	[illegible] will be telemetered to USGS, are telemetered to Pinopolis
[illegible]	[illegible] near mouth of [illegible] Creek	Specific conductance, dissolved constituents	At 5' depth intervals	Continuous 1 min readings for 10 hrs	
[illegible]	From mouth of Foster Creek as far upstream as possible	Specific conductance, Temperature, pH, Dissolved oxygen	Surface, mid-depth and Bottom	One time only for period of one to two days	Purpose is to check source of high cond. readings
[illegible]	From mouth of Chicken Creek upstream as far as possible	Specific conductance, Temperature, pH, Dissolved oxygen	Surface, mid-depth and Bottom	Once only for period of one to two days	
[illegible]	From mouth of Chicken Creek upstream to entrance to Durham Canal	Specific conductance, Temperature, pH, Dissolved oxygen	Surface, mid-depth and Bottom	Once only for period of one to two days	
[illegible]	Lake [illegible] near mouth of rediversion canal	Specific conductance, Temperature, pH, Dissolved oxygen, Turbidity, color	Mid-depth	Monthly prior to rediv. daily following rediversion until conditions stabilize, monthly after stabilization	
[illegible]	[illegible] upstream [illegible]	Specific conductance, Temperature, pH, Chloride ion	Surface and Bottom	A recon to determine location of salt front	
[illegible]	[illegible] Charleston Harbor	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible] Charleston Harbor near [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible] Charleston Harbor near [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible] Charleston Harbor near [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible] Charleston Harbor near [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible] Charleston Harbor in Town Creek near [illegible] side of [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible] Charleston Harbor near [illegible] near [illegible] bridge	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	Charleston Harbor near [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	Charleston Harbor near buoy 12 [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible] River [illegible] channel opposite [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible] near [illegible]	Specific conductance, Temperature, Dissolved oxygen, pH	Surface and Bottom	Monthly	
[illegible]	[illegible]	See Paragraph 16	One	One time prior to construction	
[illegible]	[illegible]	See Table [illegible]	Mid-depth water samples & bottom sedimt	Water samples will be collected quarterly & sediment annually	
[illegible]	At intake [illegible] point in Durham Canal	See Table [illegible]	Mid-depth water samples & bottom sedimt	Water samples will be collected quarterly & sediment annually	
[illegible]	[illegible] near Dean Hall	See Table [illegible]	Mid-depth water samples & bottom sedimt	Water samples will be collected quarterly & sediment annually	
[illegible]	[illegible] near [illegible]	See Table [illegible]	Mid-depth water samples & bottom sedimt	Water samples will be collected quarterly & sediment annually	
[illegible]	[illegible] near [illegible] Highway [illegible] bridge	See Table [illegible]	Mid-depth water samples & bottom sedimt	Water samples will be collected quarterly & sediment annually	
[illegible]	[illegible] near mouth of [illegible] Creek	See Table [illegible]	Mid-depth water samples & bottom sedimt	Water samples will be collected quarterly & sediment annually	
[illegible]	[illegible] near mouth of [illegible] Creek	See Table [illegible]	Mid-depth water samples & bottom sedimt	Water samples will be collected quarterly & sediment annually	
[illegible]	Lake [illegible] near [illegible] canal	See Table [illegible]	Mid-depth water samples and bottom sediment	Water samples will be collected quarterly and sediment annually	
[illegible]	[illegible] near [illegible] Highway [illegible]	See Table [illegible]	Mid-depth water samples and bottom sediment	Water samples will be collected quarterly and sediment annually	
[illegible]	[illegible] near [illegible]	See Table [illegible]	Mid depth water samples and bottom sediment	Water samples will be collected quarterly and sediment annually	
[illegible]	[illegible] near [illegible]	See Table [illegible]	Mid-depth water samples and bottom sediment	Water samples will be collected quarterly and sediment annually	

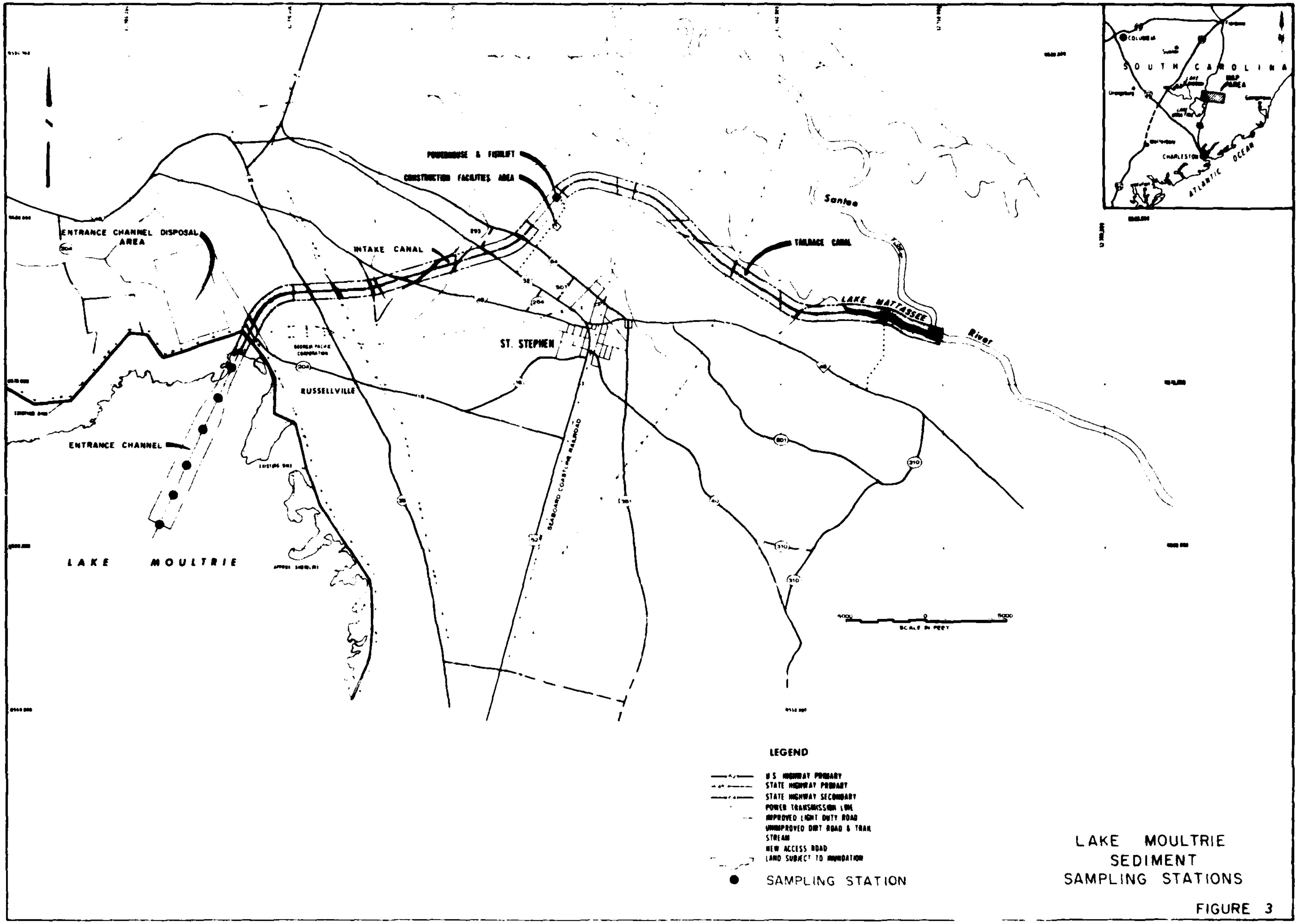


GENERAL MAP
FIGURE 1



MONITORING
EQUIPMENT ARRANGEMENT

FIGURE 2



LAKE MOULTRIE
SEDIMENT
SAMPLING STATIONS

FIGURE 3

Volatile solids
Total organic carbon (TOC)
Chemical oxygen demand (COD)
Kjeldahl nitrogen
Oil and grease
Total PO_4
NO_2N
NO_3N
NH_3N
PO_4, Soluble
Lead
Mercury

Zinc
Iron
Cadmium
Arsenic
Chromium
Nickel
Copper
Selenium
Vanadium
Beryllium
Manganese

Pesticides

Aldrin
Chlordane
DDD
DDE
DDT
Dieldrin
Endrin
Hept. Epox.
Heptachlor

Lindane
PCB
PCN
Silvex
Toxaphene
2,4-D
2,4-DP
2,4,5-T

If this sampling should indicate the presence of any constituent in the sediments in concentrations which could be harmful to aquatic life, additional water sampling would be undertaken during construction to monitor the levels of such substances in the water column.

17. Back River. In a 1976 study, the South Carolina Water Resource Commission (SCWRC) found a relatively high load of dissolved materials entering the lower end of Back River at the site of an old dredge hole near the mouth of Foster Creek. It is not known whether the high conductivities measured in this area are coming from Foster Creek or from Cooper River. To determine the source of the dissolved materials causing high conductivities, a Back River study would be performed as follows:

a. During the probable highest tides of the year, staff gages would be set to a uniform datum on Back River and Cooper River side of the dam and read on the half-hour to document tidal head difference.

b. During daylight hours, a boat with instrumentation to measure specific conductance continuously in the old dredge hole would be anchored in Back River and samples collected for analysis of the dissolved constituents. If no change in specific conductance occurs, only one sample would be collected for analysis; but if the specific conductance changes, samples would be collected hourly.

c. Specific conductance, dissolved oxygen, pH, and temperature would be measured in the field in Foster Creek, Chicken Creek, and Durham Canal and samples would be collected for laboratory analyses of the dissolved constitutents. Station locations are shown on Plate 1.

d. If conditions warrant, Back River would also be investigated along its length by measurements of the field parameters and samples collected for analysis of the dissolved constituents.

e. A limited amount of recording fathometer cross-sectional data would be gathered to facilitate other data collection.

18. Santee River. When the flow in Santee River is increased by an average of 12,600 cfs, the salt front in the estuary would be pushed downstream. In addition, the Santee Wool Combing Company has expressed concern about potential changes in water color and turbidity. To establish pre- and post-rediversion conditions, a Santee River study would be conducted as follows:

a. A reconnaissance would be made in Santee River (North and South) before and after rediversion during a period of normal flows. This reconnaissance is to determine the location of the salt wedge under these flow conditions.

b. Samples for color and turbidity would be collected monthly prior to rediversion and daily when rediversion begins at a location (S-1) just below the mouth of the tailrace canal (See Plate 1). Daily sampling would be continued until the data indicates that conditions have stabilized.

c. Prior to and after rediversion, sediment data would be collected to give an indication of sediment loading. These data would be used for comparison purposes.

d. After rediversion, the U. S. Geological Survey has indicated it would establish a National Stream-quality Accounting Network (NASQAN) at the same location. The primary objective of this network would be (1) to depict a real variability of streamflow and water quality conditions nationwide on a year-by-year basis, and (2) to detect and assess long-term changes in streamflow and stream quality. If a NASQAN is established, monitoring under the proposed plan would be terminated at that time.

19. Charleston Harbor. With a reduction of flow into Charleston Harbor, water quality changes, primarily salinity, would occur. Since adequate pre-rediversion baseline data have already been collected in Charleston Harbor by other government agencies the water quality monitoring to be accomplished under this phase of the program would

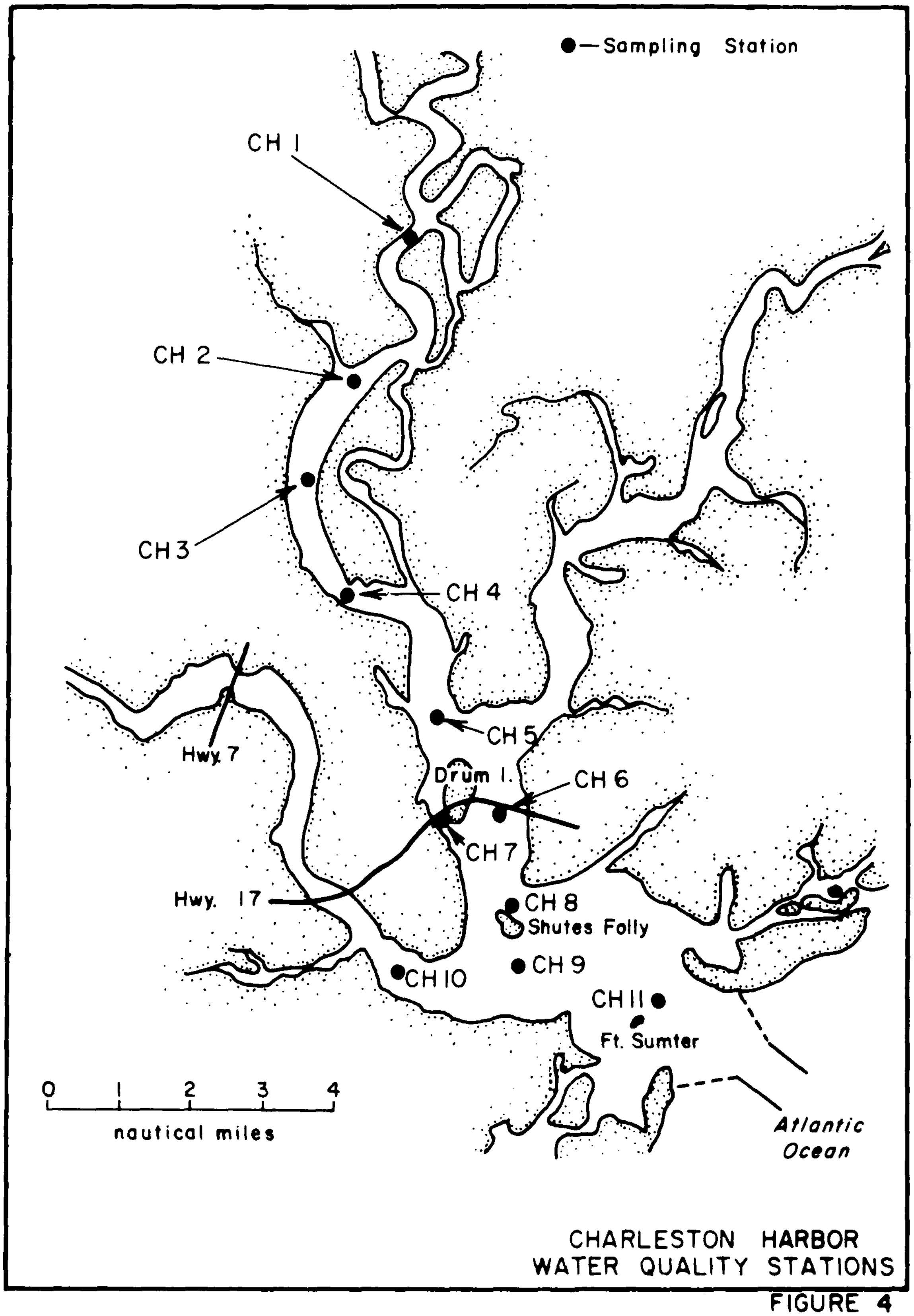
be for comparison purposes and would be accomplished after implementation of the project. Eleven stations, as shown on Figure 4, would be monitored monthly for various parameters as shown in Table 2. In addition to the above studies, WES will be conducting a pre- and post-rediversion study of current velocities, current directions, and salinities to determine the effects of rediversion on the hydraulic, salinity, and shoaling characteristics of Charleston Harbor. The plan for the studies proposed by WES is attached as Appendix A.

20. Chemical Sampling. The objective of the chemical sampling program would be to gather pre- and post-rediversion data on the chemical quality of water and sediment in the Cooper, Santee, and Back Rivers to determine if any alterations in chemical quality were being brought about by rediversion. To accomplish this objective, water samples would be collected on a quarterly basis at four stations in the Cooper River, two stations in Back River, one station in Durham Canal, and four stations in the Santee River. In addition, sediment samples would be collected at each of these stations once a year. Station locations are shown on Plate 1. Parameters to be measured at each station are shown in Table 3.

WATER LEVEL MONITORING AND STREAMFLOW GAGING PROGRAM

21. General. The water level monitoring and streamflow gaging program for the Cooper River Rediversion Project will be instituted in two phases. Phase I will cover the period prior to commencement of project operation while Phase II would cover the period following this event. Data collected during Phase I would be used primarily to establish the baseline or existing flow regime of the lower Santee River, of the tailrace canal linking the Jefferies Hydrofacility to the Cooper River, and of the Cooper River. Phase I data would also be used to verify various hydraulic design procedures and methods used in project design. Monitoring and streamflow data collected during Phase II would be used to assess the changes in the flow regimes of these river systems that have occurred as a result of the rediversion project and to monitor the operation of the Jefferies and the St. Stephen Hydroplants. Details concerning this program are discussed in the following paragraphs. The gages contained in the program are listed in Table 4 while their locations are shown on Plate 2. Except for the gages at the hydroplants, it is planned to have the U. S. Geological Survey install, operate, and maintain all the gages.

22. Jefferies Hydroplant (Pinopolis Dam). Because of provisions in the contract between Santee-Cooper and the Corps of Engineers limiting releases from the Jefferies Hydroplant, flows below this facility would have to be measured to assure that contract provisions are being met. Upon completion of the St. Stephen Hydrofacility, releases from the Jefferies Hydroplant will be limited each week to an average discharge of 3,000 cfs, but not to exceed during any day an average of 5,000 cfs. However, because this is a peaking plant, flows in the tailrace canal



CHARLESTON HARBOR
WATER QUALITY STATIONS

FIGURE 4

TABLE 3

Parameters to be Measured in Chemical Sampling

Water

Alkalinity, Total (AS Ca CO_3)	mg/l
Bicarbonate	mg/l
Calcium, Dissolved	mg/l
Carbonate	mg/l
Chloride, Dissolved	mg/l
Floride, Dissolved	mg/l
Dissolved Oxygen	mg/l
Hardness, Noncarbonate	mg/l
Hardness, Total	mg/l
Iron, Dissolved	ug/l
Iron, Total	ug/l
Magnesium, Dissolved	mg/l
Manganese, Dissolved	ug/l
Manganese, Total	ug/l
NO_2 + NO_3 as Dissolved Nitrogen	mg/l
NO_2 + NO_3 Total as Nitrogen	mg/l
pH, Field	
Phosphate, Dissolved	mg/l
Phosphate, Total as Phosphorus	mg/l
Potassium, Dissolved	mg/l
Residue Dissolved Calculated Sum	mg/l
Silica, Dissolved	mg/l
Sodium, Dissolved	mg/l
Specific Conductance, Field	umhos
Sulfate, Dissolved	mg/l
Turbidity	JTU
Water Temperature	C

Bottom Sediment

Pesticides

Aldrin Total	ug/g	Heptachlor	ug/g
Chlordane Total	ug/g	Lindane Total	ug/g
DDD Total	ug/g	PCB Total	ug/g
DDE Total	ug/g	PCN Total	ug/g
DDT Total	ug/g	Silvex Total	ug/g
Dieldrin Total	ug/g	Toxaphene Total	ug/g
Endrin Total	ug/g	2,4-D Total	ug/g
Hept Expox Total	ug/g	2,4-DP Total	ug/g
		2,4,5-T Total	ug/g

Metals

Arsenic BTM	ug/g	Lead BTM	ug/g
Cadmium BTM	ug/g	Manganese BTM	ug/g
Chromium TOT BT	ug/g	Mercury BTM	ug/g
Copper BTM	ug/g	Zinc BTM	ug/g
Iron BTM	ug/g	Nickle	ug/g
Beryllium	ug/g	Selenium	ug/g
		Vanadium	ug/g

Table 4

Stream Gaging Program

USGS Gaging Station Number	Stream	Location	Type of Gage	Const. Cost $	O & M(1) Cost $	Parameter Measured
PHASE I GAGING PROGRAM						
Jefferies Hydroplant						
02172005	W. Br. Cooper River	At Moncks Corner (Stoney Landing)	R		3,500	Stage-Discharge(2)
Cooper River						
02172020	W. Br. Cooper River	Below Moncks Corner (Pimlico)	R		(1,500)(3)	Stage
02172050	Cooper River	Near Goose Creek (Dean Hall)	R		(1,500)(3)	Stage
02172051	Cooper River	Near North Charleston (Cote Bas)	R		(1,500)(3)	Stage
Lower Santee River						
02171500	Santee River	Near Pineville	R		(4)	Stage-Discharge
New Gage	Santee River	Hwy 52 Bridge	R	1,000	3,200	Stage-Discharge
02171650	Santee River	Below St. Stephens	R		3,000	Stage-Discharge
02171700	Santee River	Near Jamestown, SC	R		3,500	Stage-Discharge(2)
02171750	Santee River	Near Honey Hill, SC	R		1,500	Stage
02171800	N. Santee River	North Santee	R		1,500	Stage
02171820	Minm Creek (N. Santee River)	AIWW North Santee	R		1,500	Stage
02171850	S. Santee River	Near McClellanville	R		1,500	Stage
02171910	S. Santee River	AIWW McClellanville	R		1,500	Stage
		Total Cost (Phase I)		$1,000	$25,200	
PHASE II GAGING PROGRAM ADDITIONS						
St. Stephens Hydroplant						
New Gage	Forbay of Intake Canal	St. Stephen Hydropower plant	R	1,000	300	Stage
New Gage	Tailrace Canal	St. Stephen Hydropower plant	R	1,000	300	Stage
New Gage	Tailrace Canal	SCL RR at St. Stephens	R	1,000	3,500	Stage-Discharge
		Total Cost (Phase II)		$1,000	$ 4,100	
		Total Program Cost		$4,000	$29,300	

Notes:
(1) Cost are for FY 78.
(2) Existing gage but discharge measurement is new.
(3) Gage cost charged to Charleston Harbor O & M.
(4) Gage cost are borne by other agencies, companies, etc.

may at any time vary from no flow to a maximum rate of approximately 28,000 cfs. To insure that procedures for measuring flows in the tailrace canal are thoroughly tested and are operational prior to completion of the rediversion project and to establish Santee-Cooper's pre-project operational mode, a stage-discharge rating for the Stoney Landing gage (03172003) would be established early in the Phase I gaging program. Because water levels at this location are influenced by tidal action, U. S. Geological Survey expects that to adequately determine flows at this location, water surface slope-discharge relationships would need to be established and a electromagnetic water current meter, to measure velocity and flow direction, would need to be installed. U. S. Geological Survey operates a stage recording gage for the South Carolina Public Service Authority in the tailrace canal immediately below the hydroplant. This gage in conjunction with the Stoney Landing gage should provide sufficient information to establish this slope-discharge relationship.

23. Cooper River. The water level monitoring and streamflow gaging program for the Cooper River will be the same as that instituted in 1964. The gages in this program are shown on Plate 2.

24. Lower Santee River (Below Lake Marion-Wilson Dam). Location of the existing and proposed stream gaging sites as well as those used only to record stage are shown on Plate 6. As shown there, only one additional gage is recommended; the one located at Highway 52. All of these gages are needed for the Phase I data collection program and during the first years of operation following rediversion (Phase II). After the changed flow regime has been well documented, some of these gages may be discontinued, such as those located at Highway 17 and the AIWW. Data collected during the Phase I program would be used to supply additional information that is needed to better define the effects of channel and overbank storage on flood wave travel times, to document pre-project conditions along the lower Santee River and to aid in further development of a mathematical model capable of predicting the water levels that would occur following rediversion. It is anticipated that after rediversion, some intermittent flooding of low-lying areas adjacent to the river would occur frequently. In order to assess the impact of this flooding and to plan future land uses, water level predictions as accurate as practical are necessary. Also for the Phase I program, stage-discharge relationships or rating curves at the Highway 52 and Jamestown gages are required. Because the gage at Jamestown is subject to tidal fluctuations, a gaging program similar to the one for the Cooper River Stoney Landing gage would be required (see paragraph 21). The slope-discharge relationship needed can probably be developed using the Honey Hill gage (02171730) located about 11 miles below the Jamestown gage. At the Jamestown gage only the lower portion of the rating curve would be influenced by tidal action since past records indicate that for the upper portion of the rating curve the tidal influence is washed downstream by flood flows (spills from Wilson Dam).

25. St. Stephen Hydroplant. Following completion of the St. Stephen Hydroplant, gaging for the Phase II program would require the installa-

tion of three additional recording gages. These would be used to monitor water levels and discharges in the intake and tailrace canals of this facility. Data collected from these gages would be used to develop discharge ratings for powerhouse turbines as well as other engineering studies. The tentative locations of these gages are shown on Plate 2.

26. Gaging program costs. A list of the proposed and existing gages and their cost is given in Table 4. Contained in the table are estimates of first-cost for gage installation, yearly operation and maintenance costs, and the type of data to be collected. As shown there, the Phase I installation and O&M costs are $1,000 and $25,200, respectively. The additional costs incurred when the Phase II program is initiated would be $3,000 for installation and $4,100 for O&M.

27. Lake Moultrie gaging program.

a. General. Lake Moultrie, which was formed by diversion of the Santee River, is roughly circular in shape, with an approximate diameter of 12 miles. At the top of power pool (elevation 75.2), it has a mean depth of about 10.5 feet. With these relatively shallow depths and long fetch lengths, the lake is particularly vulnerable to wind set-up. In order to establish the design criteria for several project features of the Cooper River Rediversion Project, it was necessary to predict wind set-up in Lake Moultrie and the wave climate in the vicinity of the entrance channel. The project features involved were the levee heights along the intake canal and the selection of controls for the fish lift facility at the St. Stephen Hydropower Plant. Information on waves was also needed to estimate the yearly maintenance costs for the entrance channel. Because the current state of the art for computing lake set-up and wave climate for lakes of this type (shallow depths and long fetch lengths), relies largely upon empirical relationships, it is recommended that a systematic prototype data collection program in the lake be adopted in order to verify these relationships. The following paragraph discusses the proposed prototype data collection program.

b. Gaging program. The tentative locations for the three new gages and the one existing gage in Lake Moultrie are shown on Plate 2. The gaging station, to be located approximately two miles from the shoreline in the vicinity of the entrance channel, would measure the wind and wave climate at this location in addition to lake stage. The equipment at this site will be housed on a platform located in the lake and would measure respectively, the speed, direction, heights, and period of the wind and waves. The gaging station sites shown near the Marion-Moultrie Diversion Canal and the community of Chicora would measure only lake stage. The existing lake stage recorder is located in the forebay area of the Pinopolis Hydroplant. These four lake stage recorders are considered the minimum necessary to adequately monitor the effects of winds on lake set-up. Current plans call for the lake monitoring program to cover about three years. The first year would be used to install and de-bug the equipment. The second and third years would be used to collect and analyze prototype data.

c. Gaging program costs. An estimate of the initial installation, operation, and maintenance cost is given in Table 5. It is anticipated that first-costs would be as high as indicated but as the bugs are worked out, second and third year costs should be less than indicated.

ANALYSIS AND REPORTS

28. General. Brief, quarterly reports will be prepared summarizing data collected. Annual reports would be prepared and will include a discussion of all phases of the study. The quarterly reports would be brief letter reports which contain data tables and charts. The annual reports would:

a. Summarize and interpret the study findings as compared to baseline water quality.

b. Recommend necessary expansions or deletions to the study program.

c. Present conclusions and findings based on the analyses made.

d. Contain a complete set of tables and charts showing the results of the study.

Special consideration would be given to the presentation of the salinity monitoring data in both the quarterly and annual reports. A summary of the data derived from the continuous monitors will be presented and any unexpected or unusual variations would be noted. Also, the maximum concentrations of chloride ion and conductivity would be noted and explained.

29. Cost analysis. Supplement #2 to General Design Memorandum No. 1, Cooper River Rediversion Project, Lake Moultrie and Santee River, South Carolina, entitled "Requirements for Protection of Bushy Park Reservoir," included an initial cost of $126,000 and an annual operation and maintenance cost of $26,000 for the water quality monitoring system. These costs were based on use of four monitors installed and maintained by the Corps of Engineers. Comparative costs presented in this DM are based on use of five monitors installed and maintained by the U. S. Geological Survey. In addition, this report includes costs for: Two temporary servo-programmers required to determine the location of two water quality monitors; a study of dissolved solids in the lower end of Back River; a Santee River study designed to determine the location of the salt wedge and monitor water color and turbidity; a chemical analysis of Lake Moultrie sediments in the intake canal; a water level monitoring and stream-flow gaging program; and model studies to be conducted by WES. The current cost is an increase of $565,600 for Construction, General and $103,300 annually for Operation and Maintenance. Costs of $126,000 for the construction portion of this work are included in the current Project Cost Estimate (PB-3) for Cooper River, Charleston, S. C.

TABLE 5

LAKE MOULTRIE GAGING PROGRAM

USGS Gaging Station Number	Location	Type of Gage	Const. Cost $	O & M$^{(1)}$ Cost $	Parameter Measured
02172000	Forebay, Pinopolis Dam	R		(2)	Stage
New Gage	NR St. Stephen, SC		21,000	19,000	Wind & Wave Data Stage
New Gage	NR Marion-Moultrie Diversion Canal	R	1,000	1,500	Stage
New Gage	NR Chicora, SC	R	1,000	1,500	Stage
Total Costs			$23,000	$22,000	

Notes:

(1) Cost are for FY78
(2) Gage cost borne by other Agencies, Company, etc.

CONCLUSIONS

30. Conclusion. The Corps should implement a water quality monitoring plan similar to that discussed in the preceding paragraphs. It should be sufficiently reliable and sophisticated to: monitor water quality changes; monitor operation of the hydropower plants; define flow regimen changes resulting from project operation; and permit early warning necessary to make releases from Jefferies Hydroplant to repel a salinity threat to industries utilizing Back River reservoir as a source of fresh water Justification for the proposed monitoring plan as a project requirement is based on the following needs:

a. To monitor the Cooper, Santee and Back Rivers, and Charleston Harbor for changes in salinity and other water quality conditions which may result from remote or unforeseen circumstances.

b. To compare salinity intrusion data between prototype and model for purpose of verifying or improving the accuracy to further model investigations and techniques.

c. To facilitate closer awareness of water quality effects of the project and develop base data which may be of significant value in appropriate conduct or assessment of various investigations of the Cooper, Santee and Back Rivers, and Charleston Harbor.

d. To determine the chemical quality of sediments in the entrance channel alignment in Lake Moultrie.

e. To monitor operation of the hydroplants (Jefferies and St. Stephen) to ascertain if contract provisions are being fulfilled.

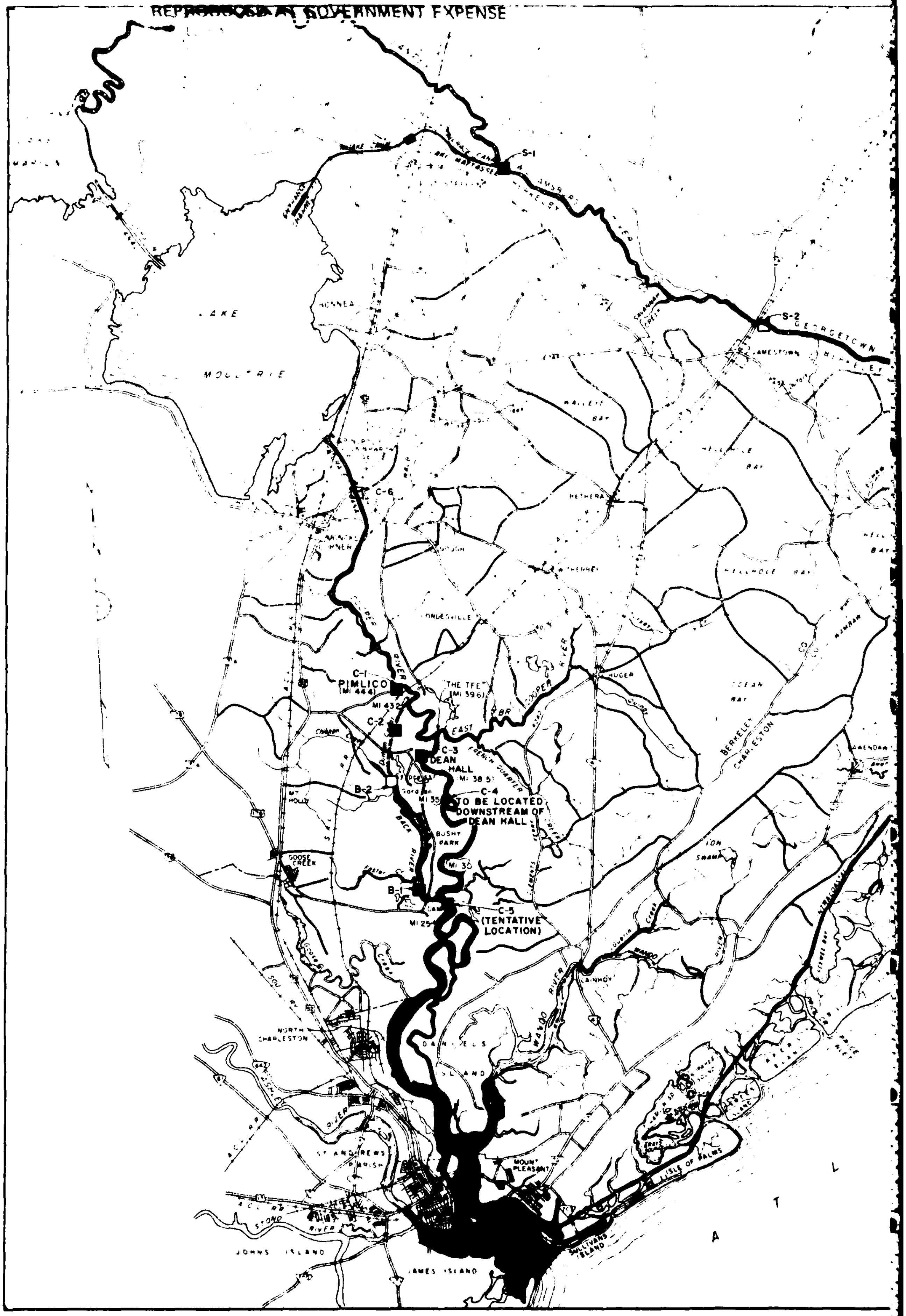
f. To document changes in the flow regimen of the Cooper and Santee Rivers.

g. To obtain prototype data for verifying estimates made of wind set-up and wave climate in Lake Moultrie.

h. To determine the effect of freshwater flow changes in Cooper River on hydraulic, salinity, and shoaling characteristics in Charleston Harbor.

31. Recommendation. It is recommended that approval be granted to the District to implement the proposed water quality monitoring plan for the Cooper River Rediversion Project.

REPRODUCED AT GOVERNMENT EXPENSE



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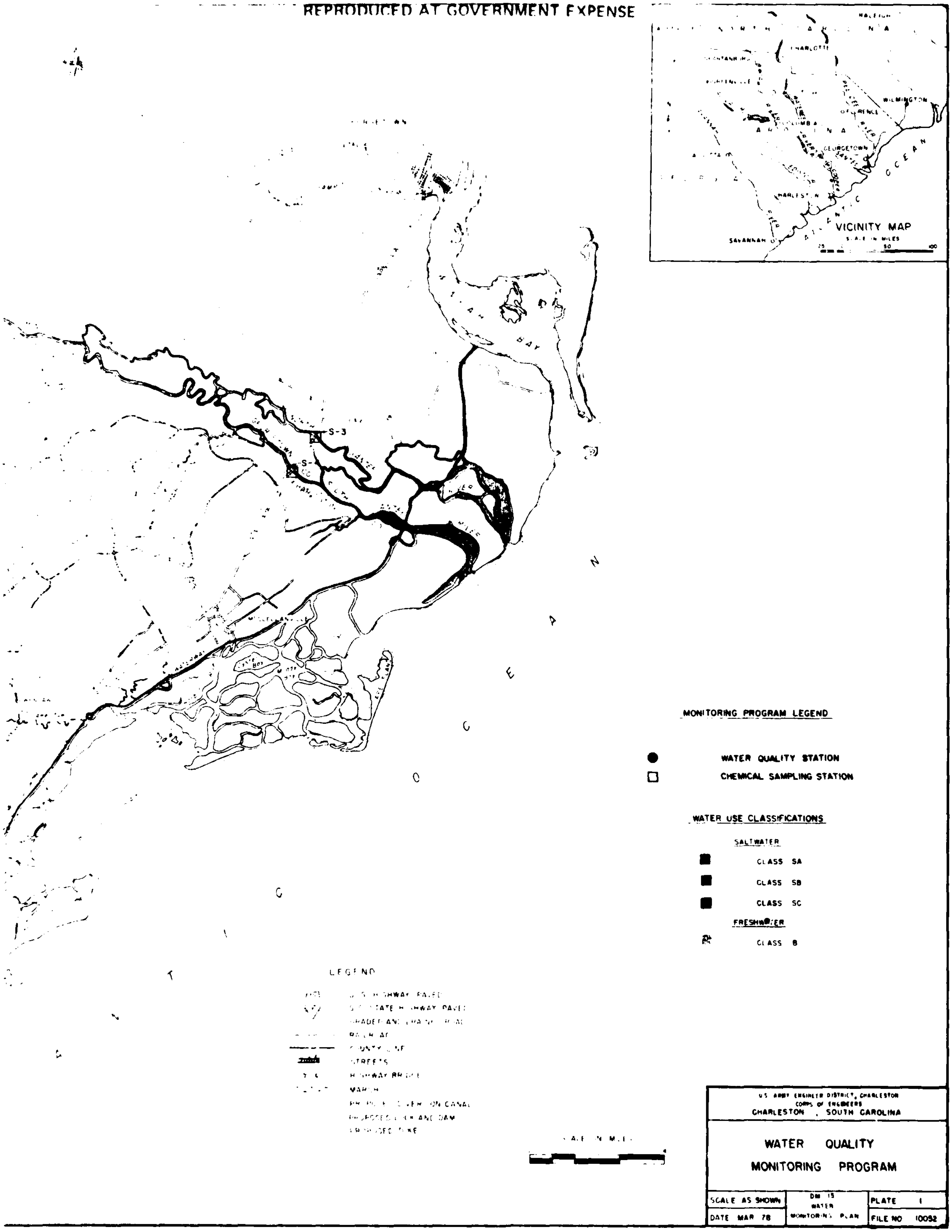
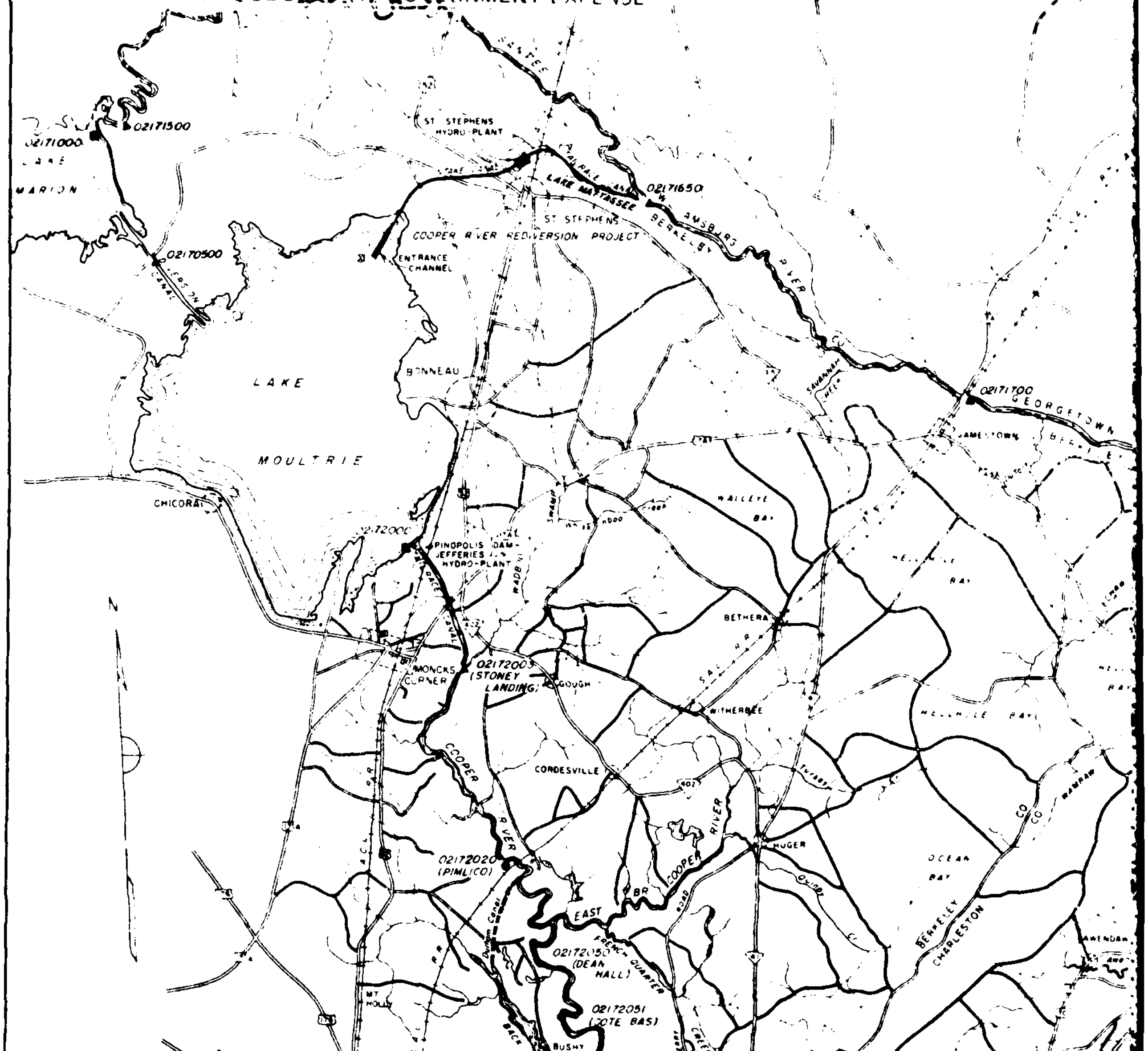


U.S. ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
CHARLESTON , SOUTH CAROLINA

WATER QUALITY MONITORING PROGRAM

SCALE AS SHOWN	DM 15 WATER MONITORING PLAN	PLATE 1
DATE MAR 78		FILE NO 10052


02171000
02171500
LAKE MARION
02170500
ST. STEPHENS HYDRO-PLANT
ST. STEPHENS
LAKE MATTASSEE
02171650
COOPER RIVER REDIVERSION PROJECT
ENTRANCE CHANNEL
SANTEE
SANTEE RIVER
BONNEAU
LAKE MOULTRIE
CHICORA
02171700
GEORGETOWN
JAMESTOWN
02172000
PINOPOLIS DAM-JEFFERIES HYDRO-PLANT
TAILRACE CANAL
WALLEYE BAY
HELLHOLE BAY
BETHERA
MONCKS CORNER
02172002 (STONEY LANDING)
GOUGH
WITHERBEE
CORDESVILLE
COOPER RIVER
HUGER
OCEAN BAY
02172020 (PIMLICO)
EAST BR COOPER RIVER
FRENCH QUARTER CREEK
02172050 (DEAN HALL)
02172051 (COTE BAS)
BUSHY PARK
MT HOLLY
GOOSE CREEK
BACK RIVER
BERKELEY
CHARLESTON
AWENDAW
ION SWAMP
WANDO RIVER
CAINHOY
MOUNT PLEASANT
CHARLESTON
ISLE OF PALMS
SULLIVANS ISLAND
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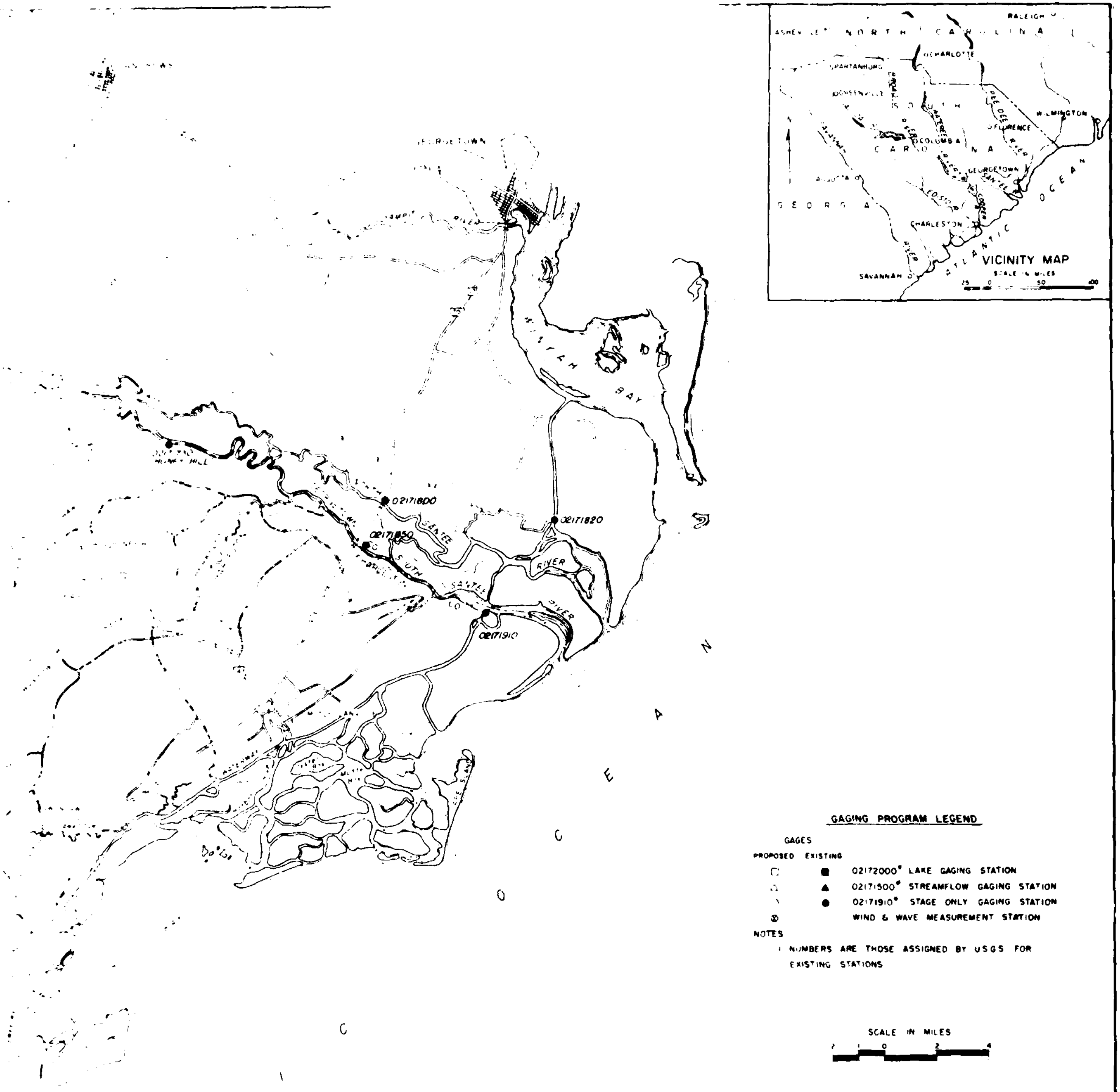


GAGING PROGRAM LEGEND

GAGES

PROPOSED	EXISTING	
☐	■	02172000* LAKE GAGING STATION
△	▲	02171500* STREAMFLOW GAGING STATION
○	●	02171910* STAGE ONLY GAGING STATION
⊗		WIND & WAVE MEASUREMENT STATION

NOTES

1 NUMBERS ARE THOSE ASSIGNED BY USGS FOR EXISTING STATIONS

SCALE IN MILES

2 1 0 2 4

MAP LEGEND

U.S. HIGHWAY PAVED
S.C. STATE HIGHWAY PAVED
GRAVEL AND [illegible]
RAILROAD
COUNTY LINE
STREETS
HIGHWAY BRIDGE
MARSH
PROPOSED REDIVERSION CANAL
PROPOSED LOCK AND DAM
[illegible]

U.S. ARMY ENGINEER DISTRICT CHARLESTON
CORPS OF ENGINEERS
CHARLESTON SOUTH CAROLINA

STREAM GAGING PROGRAM

COOPER RIVER REDIVERSION PROJECT
LAKE MOULTRIE & SANTEE RIVER SOUTH CAROLINA

SCALE AS SHOWN	DM 15 WATER MONITORING PLAN	PLATE 2
DATE MAR 78		FILE NO 10052

APPENDIX A

DESIGN MEMORANDUM NO. 15

COOPER RIVER REDIVERSION PROJECT
LAKE MOULTRIE & SANTEE RIVER
SOUTH CAROLINA

CHARLESTON HARBOR
MONITORING STUDY

U. S. ARMY ENGINEER DISTRICT, CHARLESTON
CORPS OF ENGINEERS
CHARLESTON, SOUTH CAROLINA

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
P. O. BOX 631
VICKSBURG, MISSISSIPPI 39180

IN REPLY REFER TO: WESHE

29 September 1976

SUBJECT: Charleston Harbor Monitoring Study

District Engineer
U. S. Army Engineer District, Charleston
ATTN: Mr. John C. Golden, Jr.
P. O. Box 919
Charleston, South Carolina 29402

Inclosed is a revised proposal for the Charleston Harbor Monitoring Study that supersedes the proposal furnished with our letter of 20 September 1976. The revised proposal incorporates the modifications discussed and agreed on during phone conversation of 28 September 1976 between Mr. Lesemann of Charleston District and Mr. Simmons of WES.

FOR THE COMMANDER AND DIRECTOR:

H B Simmons

1 Incl
Revised proposal

for F. R. BROWN
Engineer
Technical Director

CHARLESTON HARBOR MONITORING STUDY

Purpose

1. The purpose of the study is to determine the effect of freshwater flow changes in the Cooper River on the hydraulic, salinity, and shoaling characteristics in Charleston Harbor, which will be accomplished by monitoring the system for various freshwater flows during both pre- and post-rediversion conditions.

Methodology

2. Surveys to determine current velocities, current directions, and salinities for both pre-rediversion and post-rediversion conditions will be accomplished, and the results will be analyzed to determine the effects of the rediversion on the hydraulic, salinity, and shoaling regimens of Charleston Harbor.

Survey Ranges and Measurements

3. Six survey ranges will be located as shown in Inclosure 1. Channel centerline stations will be located at ranges 1, 2, 4, and 5. At ranges 3 and 6, stations will be located at the center and quarter points of the channel. Data from the six ranges will be collected simultaneously. Velocity and salinity data will be collected at these stations half-hourly over a complete tidal cycle (13 hr) at the surface, one-quarter depth, middepth, three-quarter depth, and near the bottom. Other than survey boats, all instrumentation and equipment for velocity and salinity measurements will be provided by WES. Water surface elevations during each survey will be measured at the existing Custom House gage and at a location upstream of the survey area. The upstream gage will be installed and maintained by WES and will be in operation at least one month prior to each survey and continue operating through each survey period.

Pre-rediversion Surveys

4. Three pre-rediversion surveys will be conducted during mean tidal conditions and normal operation of the Pinopolis power generating facility to insure that the data collected are representative. The first survey is scheduled for 1977 as requested by the Charleston District, the second and third for 1980 to establish conditions just prior to rediversion in 1981. The data collected will be as described in paragraph 3.

Post-rediversion Surveys

5. The post-rediversion surveys will be conducted during mean tidal conditions, and the data collection program will be identical to the pre-rediversion surveys. It is the understanding of WES that the freshwater

flow from Pinopolis will be reduced from 15,600 to 3000 cfs, either in one step or in increments, and the harbor will be allowed to stabilize if it is apparent that this latter flow will hold saltwater intrusion a safe distance downstream from the intake canal to the Bushy Park Reservoir. As soon as stability of the harbor occurs, the first survey will be conducted to determine the hydraulic and salinity regimens of the harbor for a controlled flow of 3000 cfs. Since certain interests would like to see the Pinopolis inflow controlled at a level higher than 3000 cfs, it is assumed for estimating purposes that two higher controlled flows will be established, the harbor will be allowed to stabilize for each, and surveys will be conducted to determine the hydraulic and salinity regimens of the harbor for each flow. From the above it is assumed that the optimum inflow at Pinopolis to best satisfy all interests will be determined, this optimum flow will be established, and two additional surveys will be conducted to firmly establish the hydraulic and salinity regimens of the harbor for this optimum flow. Thus, for estimating purposes, it is assumed that a total of five post-rediversion surveys will be required. During and between all these surveys, the continuous monitoring of salinity conditions in the vicinity of Bushy Park Reservoir will be accomplished by the U. S. Geological Survey under contract with Charleston District.

Data Analysis

6. Analysis of the survey data collected will include determination of the degree of salinity stratification in the harbor, the extent of salinity intrusion in the Cooper River, and the flow predominance characteristics along the Charleston Harbor Channel within the survey reach for both the pre-rediversion and post-rediversion survey programs.

Time and Cost Estimates

7. It is estimated that the data collection program can be completed within one year after rediversion. Assuming the rediversion will occur in 1981, the study will be conducted over a period of about five years. The preliminary estimate of cost (WES) is as follows:

Item	Time	Cost*
Data Collection (8 surveys)		
1977 - Pre-rediversion	1 wk	$ 17,600
1980 - Pre-rediversion	1 wk	20,600
1980 - Pre-rediversion	1 wk	20,600
1981 - Post-rediversion	1 wk	21,800
1981 - Post-rediversion	1 wk	21,800
1981 - Post-rediversion	1 wk	21,800
1981 - Post-rediversion	1 wk	21,800
1981 - Post-rediversion	1 wk	21,800
Data Analysis and Interim Reports		25,000
Final Report		10,000
		$202,800
10% Contingency		20,280
	TOTAL	$223,080

*Includes a 10 percent salary increase each year.

District support not included in the above cost estimate will consist of the following:

a. locate and mark survey stations.

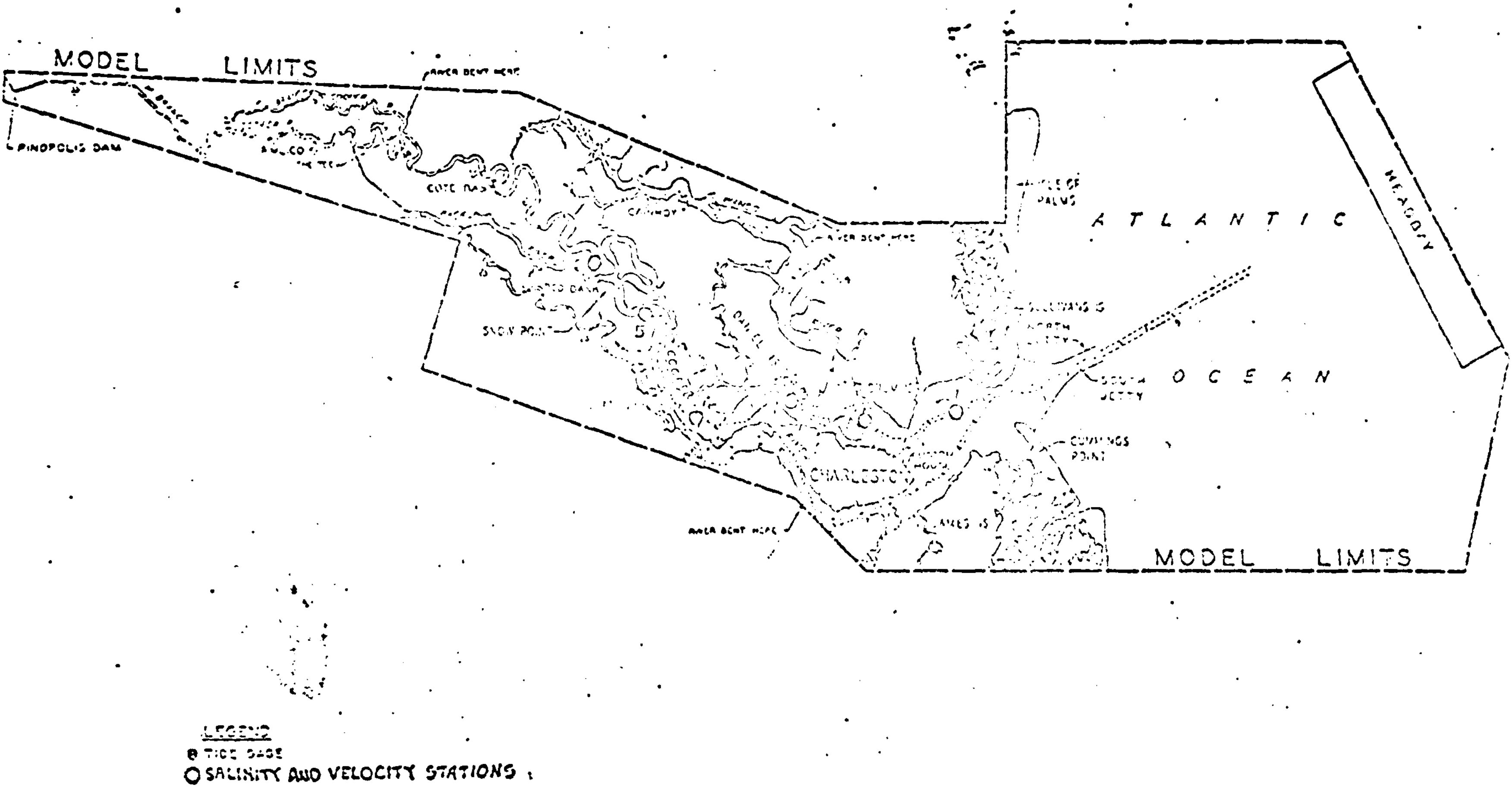
b. provide six survey boats with operators and one technician per boat for each of the eight surveys (a repair/communications boat with operator will be provided by WES and is included in the cost estimate).

c. provide freshwater flow data for each of the eight surveys.

d. provide salinity data in the Pushy Park area to be collected by the proposed salinity monitoring system.

e. provide water surface elevation data from the Custom House gage.

1 Incl
Map



LOCATION MAP

SCALES IN FEET

PROTOTYPE 10000 0 10000 20000 30000 40000

MODEL 5 0 5 10 15 20